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(54) **Method and article for restraining extrusion of feed spacers and circumferential expansion in spiral filtration modules.**

(57) An ultrafiltration module (10) and method of constructing same is the subject of the present invention. The module (10) comprises a permeate collector tube (12) and one or more membrane leaves (16) wound around the tube (12) together with a feed channel spacer (18) so as to present spaced layers of membrane leaves or envelopes that are contacted by fluid flowing axially through the module (10) in the channel provided by the feed spacer screen (18). The feed spacer screen (18) projects beyond the terminal ends of the leaves (16) to present an open mesh outerwrap screen (20) circumscribing the wound leaves (16). A plurality of restraining bands (22) are provided in longitudinally spaced relationship along the length of the module (10). These bands (22) are designed to hold the entire module assembly (10) in tight spiral relationship. Preferably, the bands (22) are constructed of heat shrinkable material and are thus secured in place and tightened by the application of heat. After the restraining bands (22) are in place, a bypass screen (24) also of open mesh configuration is wrapped around the outerwrap (20) and the restraining bands (22) and secured by overlapping it onto itself and fusing the overlapped portion.

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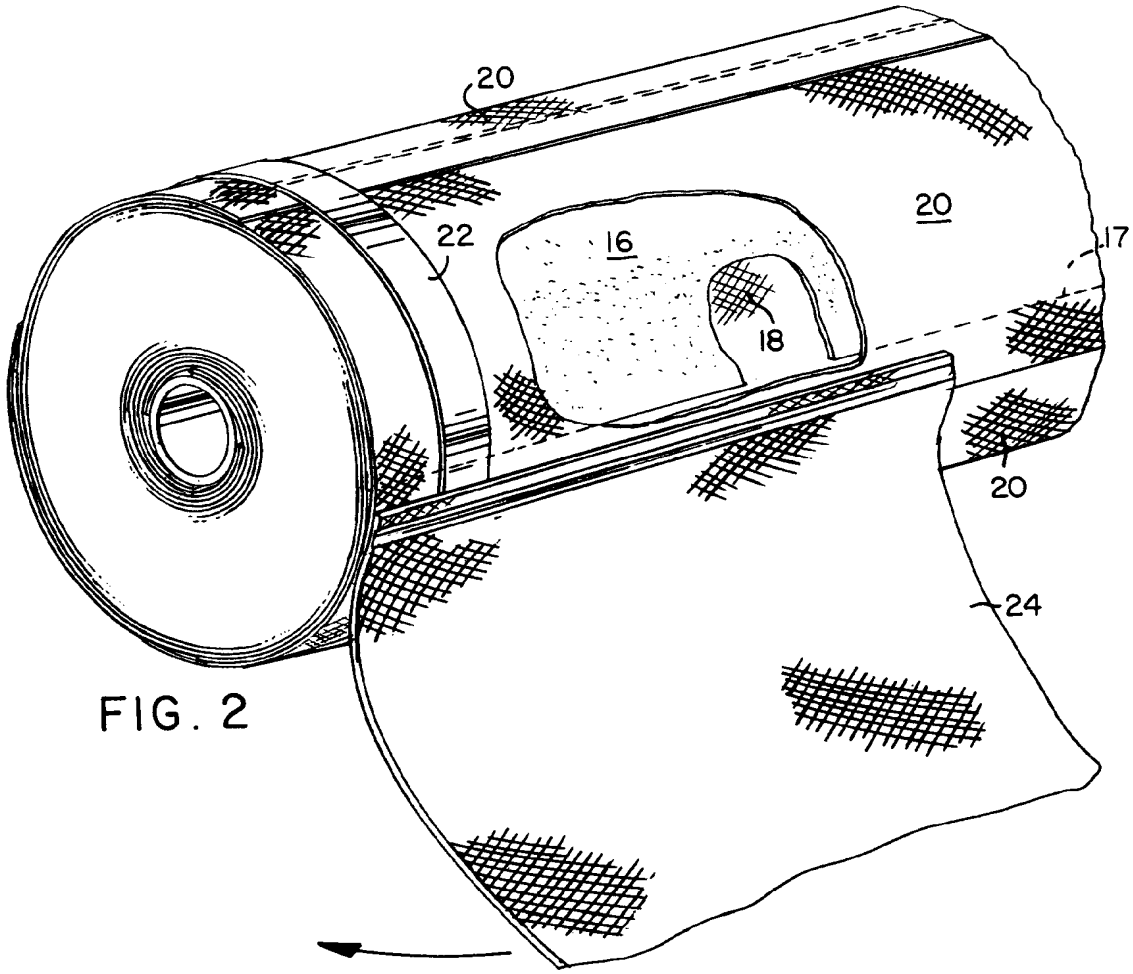

FIG. 2

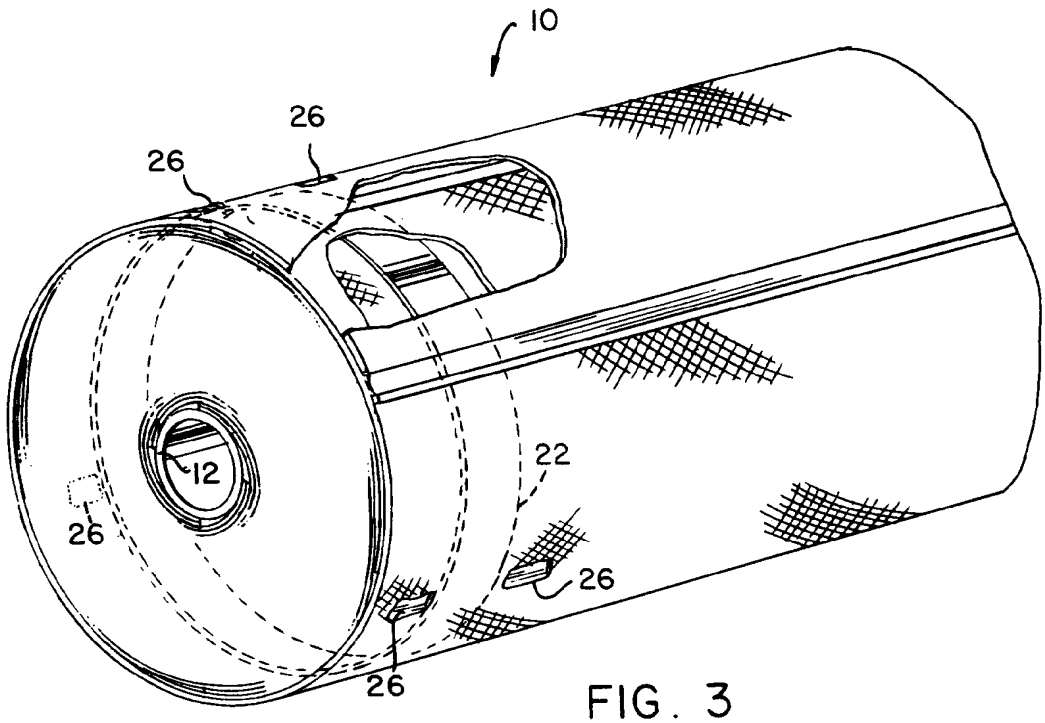

FIG. 3

This invention relates generally to ultrafiltration technology and, more specifically, to a spiral wound filtration module for use in cross flow filtration and method of construction same.

Semi-permeable membranes are utilized on both high pressure reverse osmosis and low pressure ultrafiltration and microfiltration processes. A typical design for an ultrafiltration device is to provide a spiral wrapped filtration module. Such a module is made by providing a permeate tube around which is wound one or more permeate envelopes or membrane leaves. These membrane leaves are separated by feed spacer screens. The spirally wound leaves have heretofore been held in place by a bypass spacer screen which is fused to the outside end of one layer of the feed spacer screen. The bypass screen is then wound around the circumference of the assembled leaves and ultimately fused to itself to complete the module.

The module is loaded into a housing or pressure vessel and operated at a slight pressure drop across the module. Normal flow conditions also include temperatures in the range of 80-140° F. A combination of the hydraulic forces exerted on the module and the heat from the processing operation have a tendency to soften the thermoplastic materials utilized as the bypass and feed spacer screens. This may cause the spiral to loosen reducing the frictional forces holding successive material layers and ultimately causing the feed spacer screen to extrude. Such extrusion can lead to sanitation problems and low operating efficiency caused by low flow regions attributable to the extrusion problem. The increase in outer diameter which results from the extrusion also makes the modules difficult to remove for replacement, inspection or testing.

As far as is known, there has been no prior attempt to reduce or eliminate feed spacer extrusion of circumferential expansion in spiral wound ultrafiltration modules of the type described. For non-sanitary applications, the problem is avoided by an overwrap such as fiberglass-reinforced epoxy this is allowed to harden and form a rigid outer shell for the module. This is unacceptable in sanitary applications or other uses where no stagnant flow areas are permissible since stagnant flow is inherent along the surface of the hardened outer shell.

It is, therefore, an object of the present invention to provide an ultrafiltration module and method of constructing same which substantially precludes feed spacer extrusion and circumferential expansion by circumscribing the module with one or more restraining bands.

As a corollary to the above object, it is an objective of this invention to substantially reduce or eliminate feed spacer extrusion and circumferential expansion without creating dead spaces which would adversely impact hygienic conditions or reduce operating efficiency.

Another object of the invention is to provide an ultrafiltration module which is not subject to feed spacer extrusion or circumferential expansion and a method of constructing same which will not require modification of existing pressure vessels that comprise a part of typical filtration systems.

It is also one of the objectives of our invention to provide an ultrafiltration module and method of constructing it which will not undergo significant feed spacer extrusion or circumferential expansion and which can be utilized with modules having one or a plurality of membrane leaves.

In the accompanying drawings

FIG. 1 is a perspective view of a filtration module constructed according to the present invention;

FIG. 2 is a perspective view of the module shown in FIG. 1 after the membrane leaves have been wound around the permeate tube and the bypass spacer screen has been placed;

FIG. 3 is another perspective view of the completed filtration module according to the present invention with portions broken away to illustrate details of construction; and

FIG. 4 is a side elevational view of the module according to the present invention.

Referring initially to FIGS. 1 and 3, a filtration module is designated generally by the numeral 10 (FIG. 3) and comprises an elongate permeate collection tube 12 having a plurality of holes 14 in the tube wall.

It is well known to those skilled in the art to provide an ultrafiltration module by spirally wrapping a plurality of ultrafiltration envelopes or leaves 16 circumferentially around tube 12 in the manner illustrated in FIG. 1. Each leaf 16 will normally comprise two ultrafiltration membrane sheets separated by a permeate collection sheet which may be an open mesh screen material formed from an inert composition. The leaves are secured to the tube at the opposite ends of the latter by gluing. When the membrane leaf is wrapped around tube 12 to form a plurality of layers, the layers are separated by a feed spacer screen 18 through which fluid can easily pass as a result of the open mesh construction. The length of screen 18 which separates the membrane leaves is preferably selected so that it will extend at least to the terminal end 17 of the underlying leaf.

Most preferably, the screen 18 will extend circumferentially beyond the terminal ends of the respective underlying leaves so as to present an outerwrap 20 which completely surrounds the wound leaves. Thus, in the preferred embodiment shown in the drawings, outerwrap 20 is presented by four feed spacer screens which extend beyond the terminal ends of the underlying membrane leaves and overlap each other to present an outerwrap the completely circumscribes the spirally wound leaves.

Once outerwrap 20 is in place, a plurality of restraining bands 22 are placed over it at longitudinally spaced locations along the length of the spiral assembly. Bands 22 are sized to be slightly larger in diameter than the outside diameter of outerwrap 20 so that the bands can be easily moved into position on the module. Bands 22 are preferably constructed from a heat shrinkable composition such as polytetrafluoroethylene polymer which will respond at temperatures of between 750-1000° F. applied in a localized fashion while slowly rotating the module. A typical module will require a total time of three to five minutes to completely shrink each band diameter by 10-15%.

After bands 22 are in place in tight contact with the outerwrap 20, they will hold the entire module assembly in tight spiral configuration thus precluding circumferential expansion and feed spacer screen extrusion. A final bypass spacer screen 24 is attached to the outerwrap 20 in a manner so as to overlie restraining bands 22. Screen 24 is another sheet of open mesh material. This screen is fused to the outerwrap 20 (except for the areas where bands 22 are located) and then spirally wound around the circumference of the module assembly overlapping itself slightly before terminating. The bypass screen 24 is then fused to itself in the overlap area which fused area is designated by the numeral 25 in FIGS. 3 and 4.

Next, the bypass screen 24 is fused to the outerwrap 20 at spaced apart locations designated by the numeral 26 on either side of bands 22 and circumferentially spaced around the perimeter of the assembled module 10. The fused areas 26 serve to lock bands 22 in place against movement in an axial direction along the spiral assembly.

In use, a fluid to be filtered is introduced as feed stock at one end of the housing (not shown) into which module 10 is adapted to be inserted. This feed stock passes in an axial direction along the channels created by the feed channel spacer screens 18. The permeate fraction may then enter the membrane material of the individual leaves 16 and eventually will be discharged from the membrane envelope and enter tube 12 through openings 14. The filtrate will continue to flow axially and will be removed through a separate filtrate outlet of the housing. By virtue of the ability of bypass screen 24 to pass fluid, there is no dead area between the module and its associated housing which could interrupt flow efficiency of interfere with hygienic integrity. Similarly, even though bands 22 are not capable of passing fluid, they are surrounded on all sides by screen material (outerwrap 20 and bypass screen 24) which will assure continual passage of fluid over the band surfaces thus maintaining hygienic integrity. Manifestly, bands 22 are of a sufficient strength so as to retain the original diameter of the module assembly notwithstanding the tendency of the feed spacer screen material to extrude under the operating conditions previously discussed.

It will be appreciated that the present invention also encompasses a method of constructing a spiral wound filtration module by providing a longitudinally extending permeate carrier tube, providing at least one filtration membrane leaf, providing a fluid passable spacer means on top of said membrane leaf, attaching the leaf to the tube in a manner well known to those skilled in the art, followed by wrapping the membrane leaf and the spacer means around the tube to present a plurality of spaced membrane layers. The length of the spacer means is selected so that it will extend at least to the terminal end of the outermost layer of the membrane leaf and, preferably, beyond the ends of the leaves sufficiently to form an outerwrap screen which surrounds the wound leaves. A plurality of restraining bands are tightly secured around the outerwrap at longitudinally spaced apart locations to hold the wound layers and the outerwrap in place. A fluid passable spacer means is then wrapped around the restraining bands and the outerwrap to assure the presence of a fluid passable surface on all sides of the restraining bands 22. The spacer screen 24 is secured in place by overlapping onto itself and fusing the overlapped portions together to present the completed module assembly. Preferably, the bypass spacer screen is also fused to the outerwrap at circumferentially spaced locations on either side of bands 22 so as to lock the bands in place and preclude axial movement in either direction.

The mesh material which is utilized for the feed spacer screen 18, the outerwrap 20 and the bypass spacer screen 24 may be made of various inert compositions well known to those skilled in the art. Typical material include high and low density polyolefins, such as polyethylene, polypropylene or polyester. Nylon (Reg. TM) and other materials having comparable characteristics are also acceptable.

It will be appreciated that the bands 22 may be constructed from various materials so long as the material is unreactive with the substance being filtered and is also capable of being tightly engaged with the spiral wound assembly. Likewise, the number of bands and the spacing (if any) between bands can be varied to meet the operating requirement or economics of a particular filtration module. While a plurality of bands in spaced relationship will normally be utilized, a single wide band may be suitable for a particular installation.

It will also be appreciated that while it is preferable to form outerwrap 20 by extending feed spacer screens beyond the terminal ends of the respective underlying leaves, it would also be possible to form the outerwrap by a separate screen which is fused to a feed spacer screen and then wound around the circumference of the spirally wound leaves.

The method and device of the present invention are applicable to various types of cross flow filtration

including ultrafiltration, microfiltration and reverse osmosis.

Claims

1. A spiral filtration module (10) for filtering a fluid into a filtrate portion and a permeate portion, the module (10) being arranged to be received in a housing and comprising a longitudinally extending permeate tube (12); at least one filtration membrane leaf (16) wrapped around the tube (12) to form a plurality of layers (16); and means (18) for separating the layers (16) to accommodate the flow of the fluid therebetween and for presenting an outerwrap (20) around the wound layers (16); characterised by band means (22) extending around the outerwrap (20) and in tight engagement with the latter to hold the wound layers (16) and the outerwrap (20) against expansion; and spacer means (24) extending around the band means (22) and the outerwrap (20), the spacer means (24) and the outerwrap (20) having the ability to pass fluid therethrough when the module (10) is placed in the housing.

2. A module according to claim 1, further including means (26) for joining the spacer means (24) to the outerwrap (20) on opposite sides of the band means (22) thereby precluding lateral movement of the band means (22).

3. A module according to claim 2, wherein the outerwrap (20) and the spacer means (24) both comprise thermoplastic material and the joining means (26) comprises a thermal weld.

4. A module according to any one of the preceding claims, wherein a plurality of the leaves (16) are joined to the tube (12) at circumferentially spaced apart locations, and there are a plurality of the means (18) for separating the leaves (16).

5. A module according to any one of the preceding claims, wherein the band means (22) comprises a heat shrinkable material.

6. A method constructing a spiral wound filtration module (10) of the type adapted to be received in a housing for filtering a fluid into a filtrate portion and a permeate portion, the method comprising providing a longitudinally extending permeate carrier tube (12); providing at least one filtration membrane leaf (16); providing a fluid passable separator means (18) on top of the membrane leaf (16); attaching the leaf (16) to the tube (12); and wrapping the membrane leaf (16) and the separator means (18) around the tube (12) to present a plurality of membrane layers (16) separated by the separator means (18) and a fluid passable outerwrap (20) around the wound membrane leaf (16); characterised by securing a band means (22) tightly around the outerwrap (20) to hold the wound layers (16) and the outerwrap (20) in place; and wrapping a fluid passable spacer means (24) around the wound layers (16) and the outerwrap (20).

7. A method according to claim 6, including the additional step of joining the spacer means (24) to the outerwrap (20) on opposite sides of the band means (22) so as to preclude lateral movement of the band means (22).

8. A method according to claim 7, wherein the outerwrap (20) and the spacer means (24) both comprise thermoplastic material and the joining step comprises thermal welding.

9. A method according to any one of claims 6 to 8, wherein is included the step of securing the spacer means (24) in its wrapped position.

10. A method according to any one of claims 6 to 9, comprising providing a plurality of the membrane leaves (16) and spacer means (18), and the attaching step comprises attaching the leaves (16) at circumferentially spaced locations.

11. A method according to any one of claims 6 to 10, wherein the securing step comprises heat shrinking the band means (22) around the leaf (16).

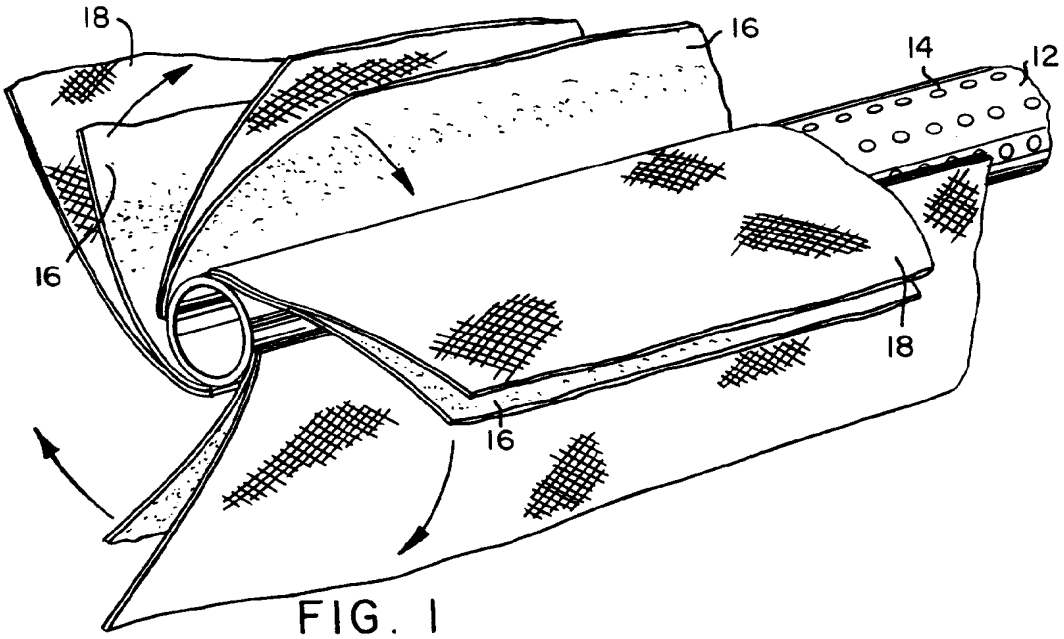

FIG. 1

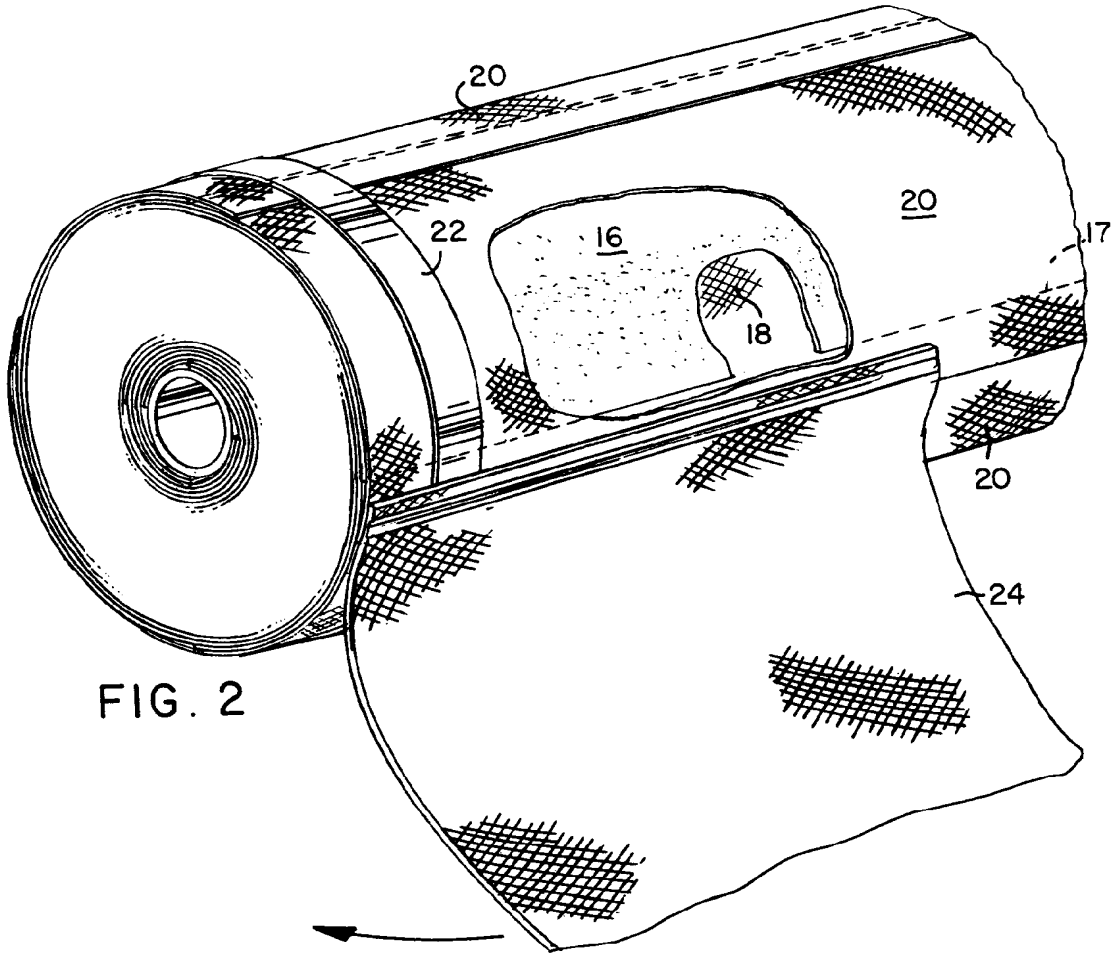

FIG. 2

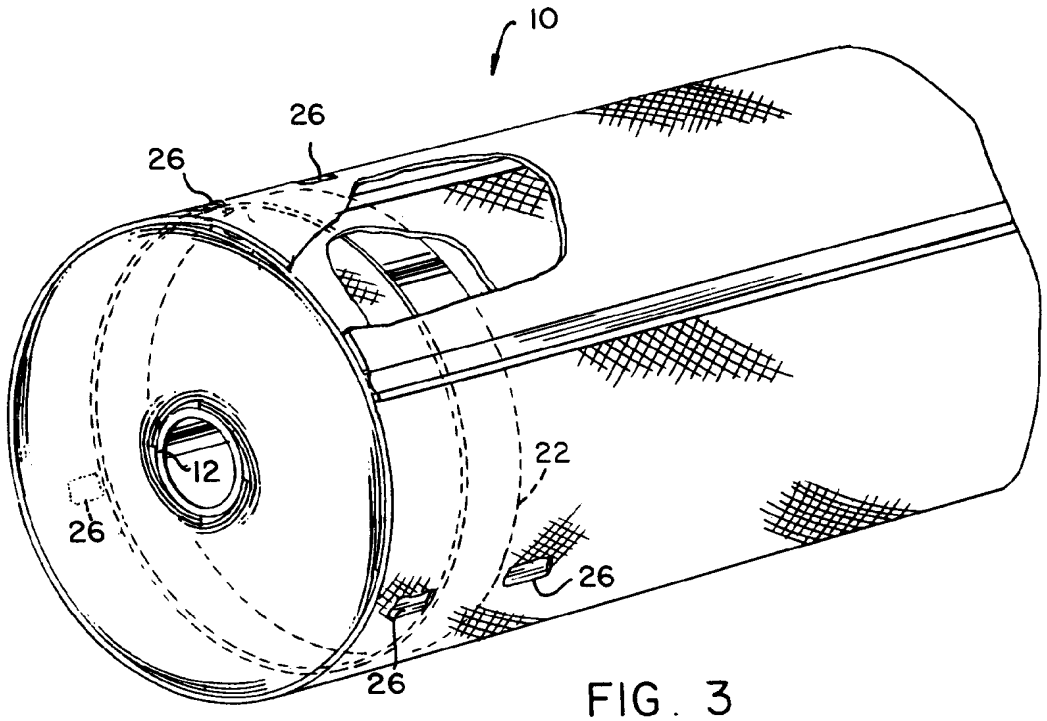

FIG. 3

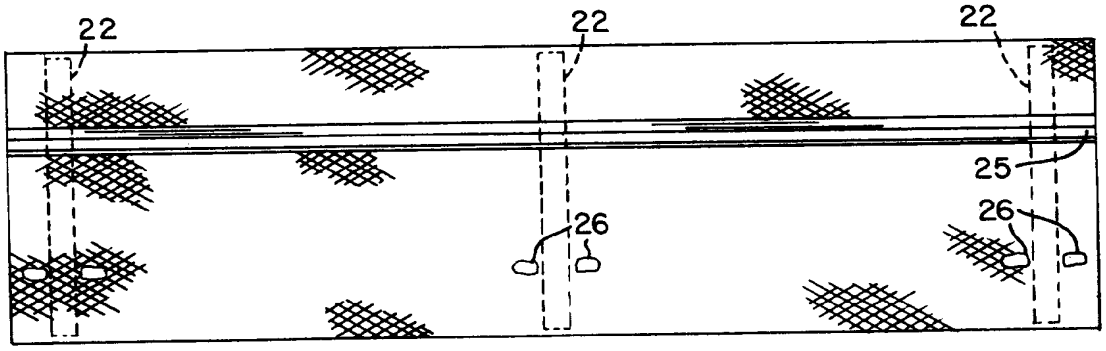

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number

EP 91 30 5164

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 347 174 (DESALINATION SYSTEMS INC) * claims 1,7; figures 4-6; column 3, lines 41-53 *	1-11	B 01 D 63/10
A	US-A-4 814 079 (B.M. SCHNEIDER) * claims; figures 3-5 *	1-11	
A	US-A-4 021 351 (D.T. BRAY) * claim 1; column 4, lines 45-48; figures 6,7 *	1	
A	EP-A-0 382 488 (KOCH MEMBRANE SYSTEMS, INC) * claims; figures 1-3 *		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B 01 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	16-12-1991	CORDERO ALVAREZ M.

CATEGORY OF CITED DOCUMENTS

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